‘Multiple dialogues with diverse viewpoints’ – one science teacher’s journey in a strange new land

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There has been much debate about the reasons for the low participation and attainment levels in science of Maori and Pacific Island students. Explanations have often been couched in terms of deficit theories that blame the victims for their own educational failure. This paper examines the nature of science as it is generally presented in the science classroom. It discusses the influences that have shaped the culture of science, and argues that students are being alienated from science because of difficulties with gaining access to its culture, and because of Western science’s presentation of itself as the only legitimate way of collecting, interpreting and legitimising knowledge of the natural world. Though this presents problems for all students, it presents particular difficulties for students from cultures other than the dominant culture. A possible approach to multicultural science education is discussed.

Introduction

My own story illustrates what is probably a common position for many science teachers. I have been enculturated into science and have accepted its objective, positivist view of the world without thinking. I have viewed my role as a teacher as delivering ‘the facts’ in the clearest way possible and have been accounted a good teacher for my success in doing so. Until recently I accepted without question that what makes science special is the application of the scientific method. As knowledge about the natural world in other cultures is not obtained in this way it cannot be science. Of course indigenous knowledge must be acknowledged, but it is not science. However, as a result of the reading I have done, I have been horrified to discover that

some would consider that my picture of science has arisen as a result of cultural conditioning.

Culture can be defined as the distinctive knowledge, language, norms and beliefs held by a group of people (Aikenhead, 1996; Hodson, 1999). Hodson (1999) argues that 'members of the dominant culture … have been socialised into seeing things from a particular perspective which becomes accepted as the 'normal' view, or even as the only view' (p.776). This view is echoed by Brickhouse (1998) '(S)ome of our assumptions are so deeply embedded that we are not conscious of them, or if we are then we hold them to be unquestionable' (p.39).

How then should I examine the nature of science as it is presented in the classroom and critically reflect on my own beliefs and practice? From my reading it seems that it is feminist scholars who are providing the strongest critique of science. Feminism cannot be categorised by a single definition and it has appropriated many different theoretical approaches (Usher & Edwards, 1994; Weedon, 1997; Brickhouse, 1998; Beasley, 1999; Andermahr, Lovell, & Wolkowitz, 2000). There is, however, general agreement among feminist scholars that patriarchy (ie the sexual system of power in which men have greater physical, social and economic power than women) is a fundamental form of domination (Brickhouse, 1998; Beasley, 1999; Andermahr et al., 2000). The assumptions underpinning patriarchy are rooted in the Enlightenment (Brickhouse, 1998).

Critical theory and postmodernism/poststructuralism provide feminists with theoretical frameworks for problematising Enlightenment inspired systems of thought and organisation, including science. Critical theory challenges 'the 'taken-for granted' assumptions that constitute social reality and social structures as homogeneous, unproblematic and predictable' (Milne & Taylor, 1998, p.27). Of poststructuralist theories Weedon (1997) says that they 'offer a set of theoretical tools which can help feminists to understand the power relations of class, gender and race in ways that help enable change' (p.180). Of postmodernism, Usher and Richards (1994) state that it 'offers a different way of seeing and working' (p.2). Postmodernism and poststructuralism are often bracketed together as if they were synonymous. Weedon (1997) describes this conflation as 'unhelpful' (p.180) but

comments that it has become a feature of contemporary feminist debate. Both sets of theories have broad features in common and so the practice of bracketing them together will be used in this paper. Postmodernism/poststructuralism has underpinned the theorising that has allowed feminists to think in terms of 'pluralities and diversities rather than unities and universals' (Usher & Edwards, 1994, p.20) and to challenge the totalising explanations and various patriarchal assumptions which stem from the Enlightenment.

Thus, feminist theorising, underpinned by both critical theory and postmodernism/poststructuralism, offers an appropriate lens with which to examine the nature of science as it is presented in classrooms, and to critically examine my own beliefs and practice. 'Theory represents understanding of the practice…'(Barrow, 1984; cited in Carpenter, 2000, p.10).

Many students, particularly those from minority cultures, are turning away from, or failing, in science (Millar, Osborne, & Nott, 1998; Fensham & Harlan, 1999; Gott & Johnson, 1999). Poor attainment and low levels of participation in science have historically been explained by deficit theories which 'blame the victim'. These explanations locate the problem in the home environment or local community and so direct attention away from institutional structures and practices in schooling and curriculum as possible problem sources (Tuioti, 1998; Hodson, 1999). Deficit explanations take for granted the education system's definitions of what counts as knowledge, learning ability and motivation; definitions which reflect the beliefs of the dominant culture (Foster, Gomm & Hammersley, 1996).

I argue that the alienation of many students, particularly those from ethnic minorities, is due to Western science's insistence that it alone can determine what counts as knowledge of the natural world and how it should be obtained. This belief is manifested in the teaching and learning programmes of most science classrooms.

Western science, universality and the science curriculum

Why am I describing science as Western? Surely science is universal and needs no qualifying adjectives? Stanley & Brickhouse (2001) argue that it is from the perspective of Western thought that Western science is seen as universal. Kincheloe

and Steinberg (1997) describe science as 'a Euro-centred ideology with parochial origins in malecenteredness and particular socioeconomic classes' (p.48). The adjective 'Western' is thus used to indicate that mainstream, or modern, science has cultural and historical roots (Cobern & Loving, 2001; Snively & Corsiglia, 2001; Stanley & Brickhouse, 2001). Kincheloe and Steinberg (1997) argue that these roots are hidden behind claims that science has trans-cultural, trans-historic universality.

Hodson (1993) describes science curricula as often portraying science as located within, and exclusively derived from, a western cultural context. Though the New Zealand science curriculum states that 'students should appreciate that social and cultural frameworks influence the way scientists work' (p.24) and acknowledges 'the contribution that different cultural perspectives make to the development of understanding in science' (p.7) (Ministry of Education, 1993), I know that in my own classroom, and probably in most classrooms, such matters would seldom, if ever, be explicitly discussed.

What is the nature of (Western) science?

Traditional Western science is underpinned with a realist view of the nature of reality that can be traced to Descartes and the mechanists of the 17th century, and to the Enlightenment in the late 18th century. A realist view of reality holds that there is a real world out there, independent of our knowledge of it, but accessible to our senses. This reality has a structure that is universal across time and place.

Science knowledge consists of, or is derived from, actual facts about the natural world. These facts can be securely established by careful use of the senses in an objective and unbiased way, providing theories and laws which are empirically testable and which represent a true picture of the world. Science knowledge is objective, neutral, and emotion and value free. This view of knowledge is described as positivism (Bauer, 1984; Fensham, Gunstone, & White, 1994; Haigh, 1998; Chalmers, 1999).

Western science sees itself as possessing the method for discovering truth and thus knowledge gained in other ways, by other cultures, cannot be viewed as science (Barton, 1998). Milne and Taylor (1998) describe the experimental report as a

discourse of power – the only way of legitimising scientific knowledge. It is this realist, positivist and exclusionist view of science, described by Harding as 'androcentric eurocentrism' (Harding, 1996, p.279), that is critiqued by feminists and others who expose the socially constructed nature of Western science and the patriarchal, epistemological and cultural hegemony that is implicit in it (Kincheloe & Steinberg, 1997; Brickhouse, 1998).

'Androcentric eurocentrism' versus 'multiple dialogues and diverse view points'

Lyotard (1994) describes the postmodern as 'incredulity towards metanarratives' (p.27). Metanarratives, such as the Enlightenment narrative of the emancipation of the rational subject, or the Enlightenment narrative of 'Universal science', are the 'totalising and comprehensive master narratives' that serve to legitimate modern practices (Audi, 1999, p.523).

Feminists and others, writing from a poststructuralist, post modernist perspective, reject the legitimating power of these 'metanarratives' and the rule of Enlightenment epistemology (Giroux, 1991a; Luke & Gore, 1992). As these writers point out, the unified rational subject of the Enlightenment, later universalised as the ideal human against which others were judged, was in practice a white, male European. This universalised human is crucially complicit in representing other groups such as women and people of 'other' cultures as lesser humans, and their knowledge as lesser knowledge (Wertheim, 1997; Beasley, 1999). Such universalising accounts marginalise what is seen as dissimilar, and are intimately connected with domination and the subordination and censorship of that which does not conform (Beasley, 1999).

The rejection of metanarratives has led to the postmodern/poststructural emphasis on plurality, the proliferation of local narratives and the opening up of the world to cultural and ethnic differences (Giroux, 1991b). A growing body of science educators is calling for a science education that avoids 'epistemological hegemony and cultural imperialism' (Cobern & Loving, 2001, p.53) and allows students to engage in 'multiple dialogues with diverse viewpoints' (Fensham, 1998, p.96). Notwithstanding this, teaching and learning in many science classrooms is still underpinned with a traditional view of science knowledge.

What is wrong with the traditional science classroom?

Three areas have been identified as contributing to the problems many students face in trying to learn science.

- The traditional roles of students and teachers

In traditional classrooms the role of the teacher is seen as the transmitter of a set body of knowledge. Students are seen as passive receivers of this knowledge with minds that can be cleared of old knowledge and filled with new knowledge by the teacher (Osborne & Freyberg, 1985; Bell, 1998).

Numerous studies, however, have provided a large body of empirical data which show that students often come to their science lessons with conceptions that do not coincide with accepted scientific thinking. These pre-existing ideas are remarkably resistant to change. Research has also shown that learning is less effective in classrooms that ignore alternative understandings which students bring (eg Osborne & Freyberg, 1985; Prain & Hand, 1995; Duit & Treagust, 1998; Palmer, 1999; Leach & Scott, 2000).

If this is generally true for students from the dominant culture, then it must be even more difficult for students from different ethnic backgrounds as there are likely to be cross cultural differences in the ways people respond to Western science (Hodson, 1999; Snively & Corsiglia, 2001; Stanley & Brickhouse, 2001). Hodson, McKinley & Tuhipa (1998) point out that, although there has been a great deal of research in the past decade or so on the importance of contextualising early science learning in the knowledge, beliefs and experiences of children, there has been little attempt to recognise the culturally specific nature of much everyday knowledge and the cultural dependency of experience, belief, values and attitudes. Hodson (1999) argues that an appreciation of the uniqueness of personal learning contexts can help to explain why students of equal ability may not learn equally, and why some may learn on one occasion and not another.

- The culture of science as it is often presented in science classrooms

The culture of science alienates many students, particularly girls and students from ethnic minorities. Students have to deal with an alien, depersonalised language (i.e.

the use of the passive voice) and are presented with unappealing messages about the nature of science and scientific practice. Students often see science as complex and difficult and accessible only to experts who have subjected themselves to long and arduous study and training. Scientists are portrayed as dispassionate experimenters who painstakingly reveal the truth about the world. Science knowledge is presented as established, certain, and not to be challenged (Aikenhead, 1996; Milne & Taylor, 1998; Hodson, 1999; Snively & Corsiglia, 2001). As Hodson (1999) states 'for many students this constitutes such a formidable barrier that they are dissuaded from seeking entry to the culture of science' (p.780). He comments that many of those who shy away from science are members of ethnic minority groups.

- Western science's view of indigenous knowledge and traditional culture

Aikenhead (1996) argues that students of ethnic minority groups often feel that being successful means losing an important part of their identity. This view was echoed at a conference held in New Zealand where it was reported that many students from ethnic minority groups believe that they have no place in science and technology education. If they do wish to study these subjects they feel they have to give up a significant part of their cultural identity (Hodson et al., 1998).

Where to now?

The New Zealand Science curriculum makes it possible to work within a multicultural framework. It clearly states that we should acknowledge 'the contribution that different cultural perspectives make to the development of understanding in science' and that '(I)n New Zealand the inclusion of Maori knowledge about the natural and physical world will enrich the curriculum for all students' (Ministry of Education, 1993, p.7). However, as Hodson (1999) warns, 'multiculturalism in science education generates considerable passion and is a source of deep controversy. There is little consensus about what it is, who it is for, and why we need it, and anyone brave or foolhardy enough to venture an answer to these questions is likely to be vigorously attacked from both extremes of the political-educational spectrum' (p.775).

'The loony doctrine'

For an example of the type of defence mounted against a multicultural position we need go no further than the furore created when the New Zealand Science curriculum

was released. It was described by Matthews (1995) as a ‘loony doctrine’ (p.12). Matthews was speaking about the supposed capture of New Zealand science education by feminists and relativists pushing, amongst other things, the notion of ‘Maori science’.

What is relativism and why do some feel that it threatens the very fabric of science? The ontological position of relativism holds that there is no independent reality. Relativism underpins a view of knowledge that is described as radical constructivism. This view holds that knowledge is not absolute, objective or universal but varies with the perceptions of the perceiver. There is no one objective truth. Any truth is as good as any other as there are no grounds for distinguishing one knowledge claim above any other (Fensham et al., 1994; Haigh, 1998; Chalmers, 1999). Bauer (1984) described the relativist position as holding that all knowledge is subjective, everything is a matter of interpretation, and that we really can’t discover anything about the world around us, if indeed there is a world around us.

If the view of reality and knowledge described above does indeed underpin the science curriculum then the storm created when it was released is not surprising. The relativist view of knowledge is in total conflict with the realist, positivist view of science that was described earlier.

Holding a feminist or multicultural view does not presuppose a relativist position and a number of writers on multicultural science specifically reject scientific and epistemological relativism (eg Bell, 1995; Hodson, 1999; Knain, 1999; Cobern & Loving, 2001). It is the ontological position of critical or agential realism (Barad, 1996) that presents a tenable position for those who reject the positivist realist view but also cannot accept a relativist position. This position holds that there is a real world out there independent of our knowledge of it but, unlike the realist position described earlier, our knowledge of it is constructed. Concepts about objects do not exist in reality but are constructed and held individually and socially. The knowledge people construct about objects is constrained by the perspective from which the object is approached, i.e. knowledge is historically and culturally bound. This view of knowledge is described as social constructivism (Bauer, 1984; Fensham et al., 1994;

Haigh, 1998; Chalmers, 1999). It is this view of knowledge, not relativism as claimed by Matthews and others, which underpins our science curriculum (Haigh, 1995).

Earlier I identified three issues with science teaching in traditional classrooms:

- The traditional roles of students and teachers
- The culture of science as it is often presented in science classrooms
- Western science's view of indigenous knowledge and traditional culture

I will now discuss each of these in the light of theoretical considerations, and make suggestions for practice.

Social constructivism for a more inclusive pedagogy

The first issue deals with the traditional roles of teachers and students. It is argued that a view of teaching and learning underpinned with a social constructivist epistemology provides for a more inclusive pedagogy and addresses the learning problems identified with the traditional roles of students and teachers (Cobern & Aikenhead, 1998; Wallace & Louden, 1998; Snively & Corsiglia, 2001). In a classroom where teaching and learning is underpinned with a social constructivist view of knowledge the teacher is a manager, uncovering students' prior views, presenting experiences in a meaningful context, challenging students' views and helping students to construct scientifically accepted understandings. Knowledge is not passively received but is actively built up by the learners who accept responsibility for their own learning in partnership with the teacher (Osborne & Freyberg, 1985; Prain & Hand, 1995; Duit & Treagust, 1998; Palmer, 1999).

However, it cannot be automatically assumed that, just because students are sitting in a classroom where teaching and learning are underpinned with constructivist principles, that they are any better off. It is possible that the messages they receive about science, and about themselves and their cultural views, are identical to the messages they would have received in a traditional didactic classroom. If the aim is simply to replace one set of cultural beliefs with another then cultural hegemony is a possibility (Cobern & Loving, 2001; Stanley & Brickhouse, 2001). Thus any social

constructivist approach must be coupled with approaches which address the issues of the culture of science and the status of indigenous knowledge.

The culture of science and border crossings

The second issue deals with the difficulty students face with the culture of science. The work of three theorists, Bourdieu, Bernstein and Giroux, though not specifically dealing with science education, helps us to understand this area of difficulty. In Pierre Bourdieu's theory of cultural capital, effective participation depends on the possession of appropriate cultural knowledge (habitus). Difficulties arise when the habitus of students is different to that of their school i.e. when their values, tastes and thoughts are different from those of the dominant culture (Harker, 1990; Hodson, 1999; Ross, 2000). As Hodson (1999) points out, science students have to make an additional transition into the culture of science where they must grapple with its values, beliefs and ways of thinking.

Science also has its own distinctive language and style of communication. Bernstein's work on language codes (Ross, 2000) helps us to understand how the everyday language codes of students are at variance with the academic language codes of science that students need to be able to use appropriately.

Giroux (1991b) points to the need for educators to prepare students for a type of citizenship that does not define community as 'the legitimating and unifying practice of a one-dimensional historical and cultural narrative' (p.245). In his notion of border pedagogy students are offered 'the opportunity to engage the multiple references that constitute different cultural codes, experiences and languages' (p.247). Students engage knowledge as a 'border-crosser', moving in and out of borders constructed around coordinates of difference and power (p.248). Giroux describes these borders as not only physical, but also cultural, 'historically constructed and socially organised within maps and rules and regulations that serve to either limit or enable particular identities' (p.248).

Hodson (1999) argues that Giroux's notion of 'border crossings' between cultures or subcultures, when applied to schooling, provides a very useful framework for thinking about how to help student learning in science. Teachers need to be more aware of the

ways in which the transition into the culture of science can be eased for those students who currently experience difficulties. Science is a subculture with its own distinctive knowledge, language, methods, rationality, criteria of validity and reliability and values, and there is a need to acknowledge the ways in which values and culturally determined meanings permeate language use in science classrooms. Hodson (1999) maintains that teachers need to make it clear when they are shifting from one subculture to another. Lemke has investigated the different registers of language that science teachers use in their classrooms and has shown that the blurring from one register to another that is so common with science teachers is a hindrance rather than the help that is intended (Lemke, 1990; cited in Hodson, 1999). Teachers need to help students to become conscious of what is required for border crossing and give them the confidence to move freely between the worlds, accessing whatever knowledge and language is appropriate and using whichever effectively (Hodson, 1999). As Aitkenhead (1996) states:

> Border crossings may be facilitated in classrooms by studying the subcultures of students' life-worlds and by contrasting them with a critical analysis of the subculture of science (its norms, values, beliefs, expectations, and conventional actions), *consciously* moving back and forth between life-worlds and the science-world, switching language conventions explicitly, switching conceptualisations explicitly, switching values explicitly, switching epistemologies explicitly but never requiring students to adopt a scientific way of knowing as their personal way (p.41).

So, social constructivist teaching and making explicit the nature of science culture and expediting border crossings can help students to become more comfortable with science. However, though these strategies could help the learning of students from cultural minorities, the specific question about the relationship between indigenous knowledge and Western scientific knowledge still must be addressed.

Indigenous knowledge versus Western science

The third issue dealt with Western science's view of indigenous knowledge and traditional culture. Snively and Corsiglia (2001) argue that in science education the

'accepted' definition of science acts a gate-keeping device for what can be included in a school science curriculum and what cannot. They argue that the definition of science should be broadened to include what they call traditional ecological knowledge. However, Cobern and Loving (2001) argue that this risks indigenous knowledge losing its distinctiveness and becoming just a token of cultural inclusiveness. They maintain that indigenous knowledge should remain a different kind of knowledge that is valued for its own merits. They argue that in maintaining a position of independence from which it can critique the nature and practices of science, it is able to play a vital role in science education.

Critical multiculturalism

So how can science teachers enable all students to study a Western scientific way of knowing and at the same time respect the ideas, beliefs and values of non-Western cultures?

Several writers on multiculturalism have argued for a critical multicultural approach, in which all students are given the opportunity to compare the ways that things are seen and described differently in different cultures i.e. to explore differences and similarities between their own beliefs and Western science concepts.

In this approach Western science and indigenous knowledge are not treated as equal but as different, providing various ways of understanding phenomena (Hodson, 1999; Snively & Corsiglia, 2001; Stanley & Brickhouse, 2001). Aikenhead (1996) has described this approach as conceptual addition. Rather than insisting on conceptual change, or the replacement of one set of worldviews (non-Western) with another (Western), both sets of knowledge are made available for use by students in different contexts. Snively has shown that it is possible to teach Western scientific concepts to students with a preferred traditional spiritual view point, without replacing the students preferred orientation (Snively, 1990; cited in Snively & Corsiglia, 2001). This approach fits well with Hodson's ideal of a multicultural science education that does no violence to the cultural beliefs of students who do not share the standard cultural beliefs of modern science (Hodson, 1993). It not only makes clear to all students the underlying characteristics of the Western science worldview (Snively & Corsiglia, 2001; Stanley & Brickhouse, 2001) but, for members of the ethnic

minority, it informs and affirms an important part of their cultural heritage (Fensham, 1998). As Rangimarie Rose Pere (1988) said 'I am learning to understand my own culture by comparing it with others and I am proud to be able to share and to contribute something that is from my own heritage' (p.19).

Conclusion

I wrote this paper in an attempt to come to some understanding of reasons why Maori and Pacific Island students under-participate and underachieve in science and what I as a science teacher could do about it. My intent was to make problematic the traditional teaching of science by challenging the 'taken–for-granted' assumptions of Western science.

> For too long, too many science teachers have taught and practised a lie: that science and science education are value free and culturally neutral (Hodson et al.,1998, p.4).

Acknowledging the concerns of ethnic minorities and developing a more culturally appropriate science curriculum does not mean abandoning scientific objectivity or diluting the science content of courses. It means that as science educators moving into an increasingly multicultural future, we must pose for ourselves the critical questions about science ('what is it?) and science education ('how should we do it'? and 'whose needs are being served?'). Such questions are likely to be disturbing because our views have been built up over a long period of time. However, as science educators we need to be challenged, and to challenge ourselves, if change is to occur. This paper articulates some of my personal challenges.

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